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Vol. V MARCH, 1918 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

SEVENTIETH ANNUAL MEETING.

THE annual meeting of the Boston Society of Civil Engineers will be held at the Boston City Club, Ashburton Place, Boston, on

WEDNESDAY, MARCH 20, 1918.

The annual meeting this year will consist, as usual, of three principal features, the order, however, being slightly changed. The annual dinner will be the first feature, followed by the business meeting and closing with the smoker.

PROGRAM.

Annual Dinner. — The thirty-sixth annual dinner will be served at 1.30 o'clock P.M., in the main banquet hall or auditorium on the fourth floor of the Clubhouse.

At three o'clock, Mr. Robert Ridgway, engineer of Subway Construction, will give an illustrated talk on "The New York Subways."

Those who find it impossible to attend the dinner are strongly urged to be present, at least, for this portion of the entertainment.

Business Meeting. — The annual meeting required by the constitution will be called to order at 5 o'clock, in one of the smaller dining-rooms on the eighth floor of the Clubhouse.

Business.—Announcement of the election of new members.

To receive the annual reports of the Board of Government, of the Treasurer, and of the Secretary.

To receive the annual reports of the several special committees.

To reappoint the several special committees.

Announcement of the result of letter-ballot for officers for the ensuing year.

Address of the retiring President.

Smoker. — The usual informal smoker will be held in the evening, in the main banquet hall, on the fourth floor of the Clubhouse, beginning at 6.30 o'clock.

S. E. TINKHAM, *Secretary.*

PAPERS IN THIS NUMBER.

"The Mesabi Iron Range." Frank B. Walker.

"The Hydraulic Laboratory of the Massachusetts Institute of Technology." George Edmund Russell.

"Effect of Heating Concrete Materials in the Mixer." H. E. Sawtell.

"Discussion of the Foundations of the New Buildings of Massachusetts Institute of Technology." J. R. Worcester.

Memoirs of Deceased Members.

CURRENT DISCUSSION.

Paper.	Author.	Published.	Discussion Closes.
"Economy in the Design of Concrete Buildings."	C. W. Mayers.	Feb.	Apr. 10.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, January 11, 1918. — A special meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order by the President,

George C. Whipple, at 8 o'clock. There were present 125 members and guests, a large proportion of the latter being ladies. An informal reception in the Society rooms preceded the meeting.

Mr. John R. Freeman, a past president of the Society, gave a most interesting talk on "The Experiences of an Engineer in the Far East."

Mr. Freeman illustrated his talk with a large number of very beautifully colored slides, made in Japan from photographs gathered by him on his trip, many of which were taken by himself.

Adjourned.

S. E. TINKHAM, *Secretary.*

BOSTON, February 20, 1918. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order by the President, George C. Whipple, at 8 o'clock.

There were 140 members and visitors present.

By vote the reading of the record of the last meeting was dispensed with and it was approved as printed in the February JOURNAL.

The President reported for the Board of Government that it had elected to membership, in the grade of member, Messrs. John McNeil Emerson, Louis John Killion, Fred Eugene Sauer, Jr., and Harry Lancaster Strand.

The Secretary submitted for Mr. Charles T. Main, the committee appointed for the purpose, a memoir of Henry A. Herrick. By vote, the memoir was accepted and ordered printed in the JOURNAL.

The President announced the death of Charles W. Gay, a member of the Society, which occurred at Lynn, Mass., on February 1, 1918, and by vote he was requested to appoint a committee to prepare a memoir. He has named, as this committee, Messrs. W. L. Vennard and Frank B. Rowell.

A communication was read from the Municipal Section of the Providence Engineering Society, extending an invitation to the members of this Society to be present at a meeting to be

held in Providence on April 24, 1918, at which Mr. Frank E. Winsor will speak on " The Development of the New Providence Water Supply to Date."

By vote the thanks of the Society were extended to the Providence Engineering Society for its courteous invitation, and the Secretary was directed to bring the invitation to the attention of the members of the Society.

A letter was read from Mr. J. R. Worcester, addressed to the Society's Committee on Legislative Affairs, calling attention to House Bill No. 1220, which deals with the engineering sections of the Boston Building Laws and is an attempt to bring them up to date.

On motion of Mr. Sherman, the thanks of the Society were voted to the Aberthaw Construction Company for courtesies extended to members who took part in the excursion, this afternoon, to the Squantum Destroyer Plant, and for its generosity in providing transportation to and from the plant.

The following vote, passed at the last meeting of the Society, was again passed by a unanimous vote, as required by the By-Laws:

> "*Voted*, that a sum not exceeding one hundred and twenty-five dollars be transferred from the income of the Permanent Fund to the Current Fund, to cover the amount of unpaid dues for the present year of members who are in the war service of the country, and which have been remitted by the Board of Government under authority of the By-Laws."

The President then introduced Lieut. Robert B. Street, chaplain of the Twenty-fifth Regiment of Engineers, U.S.N.A., which is now stationed at Camp Devens but is expected to be ordered to France at once. Lieutenant Street made an earnest plea for a contribution to the Chaplain's Fund of this regiment of engineers. He stated that the Government does not provide any funds from which a chaplain can draw to meet the many demands which come to him in his work, and he is forced to raise the money in any way he can. He therefor asked the engineers of Boston to make a contribution to this fund to be used for the welfare and comfort of their brothers who are to go to France.

The President said he would be glad to receive checks from members, to be forwarded to Lieutenant Street. Past-President

Howe said that as there was a large attendance at the meeting, he would suggest that "the hat be passed around." The suggestion was received with favor by the meeting, and as a result a very generous collection was taken up and given to Lieutenant Street.

Mr. Thomas C. Atwood, supervising engineer at the Victory Plant, then gave a most interesting address on "The Submarine Menace and the Squantum Destroyer Plant." The address was illustrated with a large number of lantern slides.

Adjourned.

S. E. TINKHAM, *Secretary.*

WITH THE 101ST ENGINEERS IN FRANCE.

ABSTRACT OF A LETTER JUST RECEIVED.

FRANCE, February 8, 1918.

My dear Mr. Sherman,—I was delighted to get a letter from you a few days ago, and I am taking this, the first opportunity, of answering it. I have had charge of two of the companies of the regiment practically since it landed in France. We have been doing a large amount of construction work under trying conditions. The men have stood up to it well, and have received many commendations from officers high in command.

We have been building what amounts to a small town, with water works, sewerage system, electric lighting, etc., and I have had to be mayor, chief of police, fire department, judge of the court, and all. Have had under me very nearly one thousand men, and it is really some little job to look after their food, clothing, medical attention and all. I have quite a contractor's organization worked up, which would be of considerable value to some contractor if it could but be turned over entire. Osbornville, as the men have facetiously called this addition to the landscape, has grown very fast. But there is other work for us to do shortly, and if I am still able to make my wrist twitch I may be able to tell you something of that other kind of work later. . . .

The regiment got together for a review, the other day, and it certainly made a fine appearance. The band, whose instru-

ments were paid for by the B. S. C. E. fund, is certainly a fine addition and much appreciated by the men. The generosity of the Society made it possible to give these hard-working boys the pleasure of listening to and marching to the martial tunes we love so well. An engineer regiment is not allowed a band, but the help of the Society was such as to give the boys something which would have been greatly missed. Its possibility I believe has had a marked effect on their health and *esprit du corps*. . . .

Very sincerely.

JOHN F. OSBORN,
Captain 101st U. S. Engineers, A. E. F.

APPLICATIONS FOR MEMBERSHIP.

[March 12, 1918.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

BRACKETT, LEROY GILE, Somerville, Mass. (Age 26, b. Biddeford, Me.) Graduate of Boston Y. M. C. A. Evening Polytechnic School, 1913, civil engineering course; has taken several courses with Massachusetts University Extension. From winter of 1911 to June, 1914, rodman, transitman and draftsman with Silverman Engineering Co.; from June, 1914, to date, with N. Y., N. H. & H. R. R. in office of division engineer and in construction

department; is now draftsman in construction department. Elected a junior April 21, 1915, and now desires to be transferred to grade of member. Refers to W. H. Bacon, C. H. Restall, Malcolm Rich and A. S. Tuttle.

SILVERMAN, MAX, Dorchester, Mass. (Age 27, b. Boston, Mass.) Graduate of Tufts College, 1914. From September, 1914, to September, 1916, with Boston Transit Com.; was employed for eight months with Mass. Highway Com.; for nine months to date, draftsman with B. & A. R. R. Elected a junior June 16, 1915, and now desires to be transferred to grade of member. Refers to S. L. Conner, W. W. Davis, P. C. Nash, F. B. Sanborn and S. S. von Loesecke.

STAFFORD, EARL, Somerville, Mass. (Age 32, b. Rockport, Mass.) Graduate of Tufts College, 1908, mechanical engineering course, degree of B.S. From 1908 to 1909, draftsman with Bay State St. Ry. Co.; from 1909 to 1910, draftsman with Boston Bridge Works; from 1910 to 1911, designer on miscellaneous water-power development work with Ambursen Co., of Boston; from 1911 to 1914, designing engineer with George F. Hardy, Boston, and consulting engineer, New York, on paper and pulp mills and hydro-electric developments; from 1914 to 1915, designer with Power Construction Co. on Deerfield River developments in Massachusetts; from 1915 to 1916, designing engineer with Fargo Engrg. Co., Jackson, Mich., on hydro-electric developments; from 1916 to 1917, designing engineer with Utah Copper Co. in Utah and Chino Copper Co. in New Mexico; is now assistant to John F. Vaughan, Cons. Engr., Boston. Refers to H. L. Coburn, E. A. Norwood, Malcolm Rich, H. C. Whitmore and D. M. Wood.

LIST OF MEMBERS.

ADDITIONS.

JONES, PUSEY.....Room 304, North Station, Boston, Mass.

CHANGES IN ADDRESS.

BARNES, T. HOWARD.....50 Rockland Ave., Yonkers, N. Y.
BOWERS, GEORGE W. .....Care A. Bentley & Sons Co., Jacksonville, Fla.
COFFIN, SAMUEL P.....1299 Commonwealth Ave., Allston, Mass.
COGHLAN, JOHN H.....5057 Summer St., Philadelphia, Pa.
CURTIS, ALLEN.....Room 8, Union Station, Worcester, Mass.
DEMERRITT, ROBERT E.,
2d Lieut., Coast Artillery Corps, Fort Monroe, Va.
EDDY, H. PRESCOTT, Jr.....Norfolk Navy Yard, Norfolk, Va.
FARRELL, FRANCIS B.....113 Atlantic Ave., Atlantic, Mass.
FLINN, ALFRED D.....Room 901, 29 West 39th St., New York, N. Y.
FREED, CHARLES.....12 Greenock St., Dorchester, Mass.
HALL, CHARLES LORING,
Care Isaac Prouty & Co., 133 Main St., Spencer, Mass.

HARTY, JOHN J., Jr.,
Capt. Ord. Dept., U.S.R., Springfield Armory, Springfield, Mass.
HUNTINGTON, FREDERICK W. ..... Belcher St., Holbrook, Mass.
HURD, STEPHEN P. ..... 644 Adams St., E. Milton, Mass.
LEE, EDWARD G. ..... Care Southern Power Co., Charlotte, N. C.
LEWIS, GEORGE W. ..... Care Hugh Nawn Contracting Co., Hog Island, Pa.
PERKINS, THEODORE P. ..... 352 North Station, Boston, Mass.
PORTER, ARTHUR P. ..... 15 Glen Rd., Newton Lower Falls, Mass.
POWER, WILLIAM J., Jr. ..... 5 Grant Pl., Waltham, Mass.
SILVERMAN, MAX ..... 26 Fernboro St., Dorchester, Mass.
SMITH, CHESTER W. ..... 160 Middle St., Portsmouth, N. H.
SOUTAR, GEORGE P. ..... Care U. S. Weather Bureau, Boston, Mass.
STARR, JOHN A. ..... Box 411, Chatham, Mass.
STENBERG, THORNTON R. ..... 23 Burncoat St., Worcester, Mass.
STROUT, HENRY E. ..... Lieut., Camp Fremont, California
WOODBURY, STANLEY W. ..... 15 Mall St., Salem, Mass.

DEATH.

GAY, CHARLES W. ..... February 1, 1918

EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

MEN AVAILABLE.

418. Age 32. Received technical education at Brown University, class of 1909, civil engineering course. Has had two years' experience on railroad construction and surveying, one year on topographical and city surveying, and four years on construction work. Desires position as engineer on construction work. Salary desired, $45 per week.

419. Age 36. Graduate of Mass. Inst. of Technology, civil engineering course. Experience includes about five years in west on railroad location and canal surveys, six years in office of engineer of structures in Boston, and five months on design of steel and reinforced concrete for steam power houses. Desires position as chief draftsman on structural steel or concrete. Salary desired, $170 per month.

420. Age 50. Graduate of Harvard University, 1890; regular student for three years, Mass. Inst. of Technology; member of Society. Experience as follows: Six years on sewerage, water works, and general municipal engineering; about twenty years as assistant engineer with Boston Elevated Railway Co. on land takings, estimating abutters damages, abolition of five grade crossings, estimates and designs of subways and stations and the complete requipment of stations; investigation of elevated and subway routes and location of stations. Desires position on investigation or construction work. Salary desired, $200 per month.

LIBRARY NOTES.

Recent Additions to the Library.

On Military Engineering and Related Subjects.

Elements of Military Sketching and Map Reading. Capt. John B. Barnes.

U. S. Government Reports.

Annual Report of Chief of Engineers, U. S. Army, for 1917. 3 vols.

Bibliography of Recent Literature on Flotation of Ores, July to December, 1916. D. A. Lyon and others.

Blast-Furnace Breakouts, Explosions, and Slips, and Methods of Prevention. F. H. Willcox.

Cost Accounting for Oil Producers. Clarence G. Smith.

Effects of Grazing upon Western Yellow-Pine Reproduction in National Forests of Arizona and New Mexico. Robert R. Hill.

Firing Bituminous Coals in Large House-Heating Boilers. S. B. Flagg.

Mineral Resources of United States, 1915: Part II, Nonmetals. E. F. Burchard.

Suggestions for Safe Operation of Gasoline Engines in Mines. R. H. Kudlich and Edwin Higgins.

Use of Waterways a War Necessity. Hon. Joseph E. Ransdell.

Waterways and Harbors of United States. S. A. Thompson, Ed.

State Reports.

Massachusetts. Report of State Board of Health upon Sewerage of City of Salem and Town of Peabody, 1896. Gift of A. F. Brown.

Municipal Reports.

Chicago, Ill. Report relating to Existing Lake Levels, 1917. George M. Wisner.

Chicago, Ill. Water Works System of Chicago, 1917. Bureau of Public Efficiency.

Fitchburg, Mass. Reports of Sewage Disposal Commission for 1910 to 1917, inclusive, bound in one volume. Gift of D. A. Hartwell.

Providence, R. I. Annual Report of Department of Public Works for 1917.

Miscellaneous.

Canada, Department of Interior, Topographical Surveys Branch: Description, Adjustments and Methods of Use of Six-Inch Micrometer Block Survey Reiterating Transit Theodolite, 1912 Pattern. W. H. Herbert.

Canada, Department of Mines: Summary Report of Mines Branch for 1916.

Industrial Arts Index for 1917. Charlotte G. Noyes and Louise D. Teich, Ed.

Power Specialty Co.: Superheated Steam.

Washington's Nine Months at War. Raymond B. Price.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

Commonwealth of Massachusetts. — METROPOLITAN PARK COMMISSION. — *Old Colony Parkway.* — Construction of a temporary bridge across the Neponset River between Boston and

Quincy is in progress; also construction of double siphon for water and gas under new channel.

Boston Transit Commission.—*Dorchester Tunnel.*—Work is progressing on the interior finish of the station at Andrew Sq., and work is in progress on the station for transfer of passengers from the surface cars to the tunnel below.

Boylston Street Subway.—Work has been started on the surface station for the transfer of passengers to and from the Massachusetts Station of the Boylston Street subway.

City of Boston.—Public Works Department, Highway Division, Paving Service.—Work is in progress on the following streets:

Alger St.,	from Dorchester Ave. to N. Y., N. H. & H. R. R.	Moving buildings.
Pontiac St.,	from Tremont St. to Hillside St.	Blasting rock.
Grove St.,	from Centre St. to Washington St.	Taking down trees.

New York, New Haven & Hartford R. R. Co.—*South Boston Cut Improvement.*—Enlargement of South Boston Cut to Boston Freight Terminal, to accommodate four tracks instead of two, and reconstruction of eleven overhead highway bridges, so as to span four tracks instead of two, progressing. Excavation by steam shovel has advanced from westerly end of cut to Silver St. Bridge abutments being constructed at West Sixth St. and West Fifth St. Concrete work retarded owing to extreme cold weather. Permanent pumping plant being constructed at Dorchester Ave.

Vol. V MARCH, 1918 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

THE MESABI IRON RANGE.

By Frank B. Walker,* Member Boston Society of Civil Engineers.

A talk on the mining and hauling of coal would have been appropriate to these heatless days, but probably we are as much interested in the question of an adequate supply of iron and its products as any other.

The Germans say that this is a war of "Blood and Iron," and well they know it. The terrible struggle which Germany is making to retain Alsace-Lorraine is not for the beauty of its mountain scenery, but to retain the very rich potash and iron ore fields of these two beautiful French provinces. More than any other thing, the iron ore of Lorraine has made Germany industrially great. If France had taken Lorraine in 1914, Germany would have been defeated in 1916. Steel men claim that Germany's gigantic drive at Verdun was not so much to take Paris, as it was to close the mailed fist absolutely around the high-grade iron ore district of Briey, which is an extension of the Lorraine ore bodies and contains a much higher grade of ore. Briey is about twenty-five miles east of Verdun.

You may be interested in the steel producing capacity of our country in comparison with Germany. The estimated production in the United States for 1918, is 48 500 000 tons, and a year ago it was 43 000 000 tons. Under stress of war, our steel

* Special Engineer in charge of bridge work, Bay State Street Railway, 245 State Street, Boston, Mass.

men have increased our steel production 13 per cent. Germany has an estimated annual production of steel ingots of 20 000 000

FIG. 1. LOCATION OF THE MESABI IRON RANGE IN MINNESOTA.

tons, against 16 000 000 tons a year ago. England's estimated annual production is 12 000 000 tons, against 8 000 000 tons a

year ago. The estimated world's production for 1918 is 100 000-000 tons of steel, of which we make 48½ per cent.

Now, where do we produce the millions and millions of tons of iron and steel required for munitions, ships, rails, locomotives and thousands of other war purposes? I shall attempt to partially answer this question by giving you a few figures and showing you a few pictures of some of the iron ore mines on the Mesabi Range, Fig. 1, and ore docks in northern Minnesota.

There are three iron ranges or districts in Minnesota. The Vermilion, opened up in 1882, is about fifty miles northeast of the Mesabi, and the Cuyuna, opened up in 1911, is about seventy-five miles southwest of the Mesabi. A diagram, Fig. 2, is shown indicating the relative importance of the two latter ranges. The Duluth-Superior Harbor, at the head of Lake Superior, is about seventy-five miles away from the nearest point of the Mesabi Range. Hibbing is eighty-six miles from Duluth on the Duluth, Mesabi & Northern Ry., and one hundred and twenty miles from Superior on the Great Northern. This harbor, lying in Minnesota and Wisconsin, ships more ore than any other port in the world.

The Mesabi Range is about 75 miles long, and from ½ mile to 3 miles wide. The western end of the range merges into the level of the surrounding country and lies at an elevation of 1 400 ft. above sea level, or 800 ft. above the level of Lake Superior. At the eastern end, near Virginia, the elevation increases to 1 800 ft., or 1 900 ft. above sea level, or about 400 to 500 ft. above the level of the surrounding country. This ridge is called the "Giant Range," "Mesabi" being the original Chippewa Indian name for Giant. There are no mountains in Minnesota. The timbers and soil are characteristic of the lake region. The forests include white and yellow pine, tamarack, spruce, cedar and balsam, with some poplar, birch and maple. However, old choppings, windfalls and many swamps have combined to make the scene a desolate one, and the immense open pits and mountain-high waste dumps, made from mine strippings, do not add to the beauty. Yet all this can be forgotten when it is realized that here is one of Nature's treasure stores, the richest and most productive iron ore district in the world. The

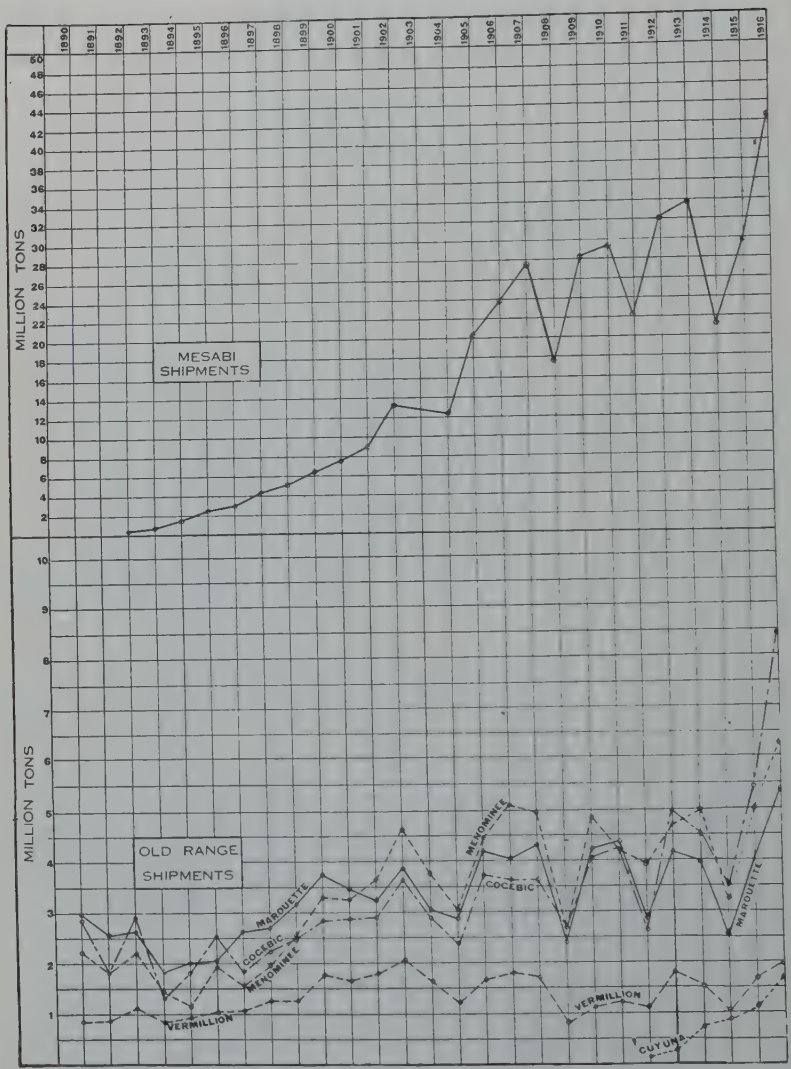

FIG. 2. CHART SHOWING SHIPMENTS OF IRON ORE FROM MESABI RANGE, 1892–1916; OTHER RANGES, 1890–1916.

iron ore found on the Mesabi is called by geologists hematite or ferric hydrate. Following is an analysis of Mahoning ore. Note the high iron content of 62.6 per cent. in this ore.

ANALYSIS OF IRON ORE FOR
GREAT NORTHERN IRON ORE PROP.
Hibbing, Minn., M., Nov. 2, 1917.

Dried at 100° C.	Per Cent.
Iron	62.64
Phosphorus	.055
Manganese	.47
Silica	4.38
Alumina	2.13
Lime	.18
Magnesia	.15
Sulphur	.011
Loss by Ignition	3.02
Moisture	9.80
Natural Iron	....

Lab. No. 452716
Remarks. Mahoning Mine, No. 3040.
.....
.....
Analyzed by Lerch Bros.

The ore occurs in isolated bodies or lenses. It lies near the surface, rarely more than 300 ft. deep, is fairly soft and is usually covered with glacial drift, consisting of sand, clay and bowlders. This is called the "over-burden." Mesabi ore is similar in most respects to ore from the so-called older ranges, but differs from these ores in being located so near the surface, and in being much softer. These two characteristics are responsible for its being mined to such a large extent in open pits by steam shovels. Only about 20 per cent. is mined by the underground or shaft method.

The *Iron Trade Review* has kindly permitted me to show you a graphic record of shipments by ranges for the last twenty-seven years, Fig. 2. These and all other figures are in gross tons of

2 240 lbs. I do not want to bore you with dry statistics, but a few figures seem necessary.

In 1916, the Mesabi shipped 42 525 000 tons, and
In 1917, the Mesabi shipped 40 583 000 tons.

The Vermilion and Cuyuna, combined, shipped, in 1916, 3 663 000 tons, and in 1917, 3 953 000 tons. In 1916, the Gogebic, Marquette, Menominee and other smaller ranges shipped 20 469 000 tons, and in 1917, 20 246 000. Total shipments Lake Superior:

1916.....66 million tons,
1917.....64 million tons,

or 85 per cent. of all iron ore mined in the United States.

The falling off of the Mesabi shipments in 1917 was due to the late opening of navigation on Lake Superior. In 1916, boats got started April 22, but in 1917, it was early in June before navigation opened.

It takes about two tons of iron ore to make a ton of steel, so you can readily see what the Mesabi Range is doing to win this war; and, further, do not be alarmed about our running out of ore, as it is estimated that Minnesota has reserves of 1 463 860-000 tons of merchantable ore, of which 90 per cent. is on the Mesabi Range, or enough for thirty-five years at the present rate of mining. The present price of Mesabi Non-Bessemer iron ore, lower lake ports 51½ per cent. iron, is $5.05 per ton.

There are 121 active mines on the Mesabi Range, and 8 shipped over one million tons in 1916. The Hull-Rust made shipments of over 7 million tons in 1916, and shipped in 1916 and 1917 over 14 million tons of ore. This mine is owned by the United States Steel Corporation.

Diamond drilling outfits are always a part of the scenery on the Range. Most exploration work now is carried out by diamond drills. I would not make a guess as to the number of drills operated, but it must run into many hundreds.

Mr. H. H. Eames, in 1866, reported immense bodies of magnetite and hematite ore in this region, and for many years there was more or less exploring. In 1890, the Merritts of

Duluth, who were among the persistent explorers, were rewarded for their faith, as their test pit crew struck ore in the northwest quarter of Town 58, No. Range 18, west, just north of what is now the Mountain Iron Mine, four miles west of Virginia. The discovery of ore at other points rapidly followed.

The Merritts, in 1894, built a line, the Duluth, Mesabi & Northern, from Mountain Iron Mine to Brookston on the Great Northern; and the Great Northern built a small ore dock on the Superior Harbor; and the first ore was shipped over this route in 1894. In 1906 and 1907, it became my duty to remove this dock, then twelve years old, and replace it with what is now Great Northern Ore Dock No. 1, the largest ore dock ever built, up to that date. The Merritts extended their line to Duluth, and through a $600 000 mortgage, their whole property fell into the hands of the Rockefellers, who later turned these properties over to the United States Steel Corporation when that corporation was formed. The Duluth & Iron Range is also owned by the corporation. The Steel Corporation interests are in the name of the Oliver Iron Mining Company, and the Oliver shipped 43 per cent. of all Mesabi ore in 1917, — 47 per cent. in 1916, and 50 per cent. of all ore during the past ten years. The Great Northern Railroad also has very large ore holdings on the range, but these properties are being disposed of to the so-called independents. M. A. Hanna & Co. recently purchased 40 to 50 million tons, and Jones and Laughlin a large tonnage.

I had charge of the engineering work for the Great Northern Railroad on the Mesabi Range and the Lake Terminals for many years, and even though I visited the range several hundred times, I never ceased marveling at the vastness of the operations involved in the stripping, loading and hauling of this ore. Hundreds of locomotives and steam shovels were in operation day and night, with heavy blasting at every meal hour. Just imagine, if you please, loading 7 660 000 tons in less than two hundred working days from one mine. This would make 3 860 000 tons of steel, or enough to lay 20 000 miles of railway with 100-lb. rail, including fastenings; or enough ore to make steel rails to relay the entire Bay State Street Railway in seven days.

FIG. 3. SHINANGO MINE — SHOWING OPEN-PIT MINING OPERATIONS.

The railway companies build spurs and yard tracks to serve each mine, and deliver empty ore cars to this yard as many times a day as required; the mine locomotives take the empties into the pits, where they are loaded by steam shovel, 50 tons per car, and then returned to the yard. The Mahoning requires 250 to 300 cars, and the Hull-Rust 700 to 800 cars each twenty-four hours.

Eighty per cent. to ninety per cent. of the ore is mined by stripping off the over-burden with steam shovels and then building standard gage railroad tracks down incline into the mine and loading the ore on to the railroad cars by steam shovel. This over-burden is 20 to 40 ft. thick and can be readily distinguished from the ore in the pictures. Figs. 3, 4 and 5.

One contractor, while I was on the range, stripped one mine of seven million yards of over-burden. John F. Stevens, formerly chief engineer of the Great Northern, and later of the Panama Canal, said that more material was loaded on the Mesabi than was loaded on the canal in the same length of time.

For a long time, it was thought that there was too much sand in the ore on the western end of the range; but several years ago the Wisconsin Steel Company — owned, I think, by the International Harvester Co. — put up a washer at the Hawkins Mine. This was successful, and there are about a dozen plants in operation or under construction. One peculiar result is that washing the ore reduces the moisture content.

Shaft mines work all winter, and put the ore in stock piles. This is shipped out after navigation opens up in the spring. Open pits shut down mining about December 1, and only carry out stripping operations during the winter.

The Grant Mine is owned by the Jones-Laughlin Company, and their engineers conceived the idea of stripping and mining by means of a big clam shell. The experiment cost them a half million dollars and they had stripped 60 000 yards, when the outfit was pronounced a failure by the owners. Others had pronounced its fate earlier in the proceeding.

The capacity of the bucket was 11 yds., and the stock was $1\frac{1}{2}$ in. thick. Every time it broke down — and that was frequently — a car had to be furnished to ship it away for repairs.

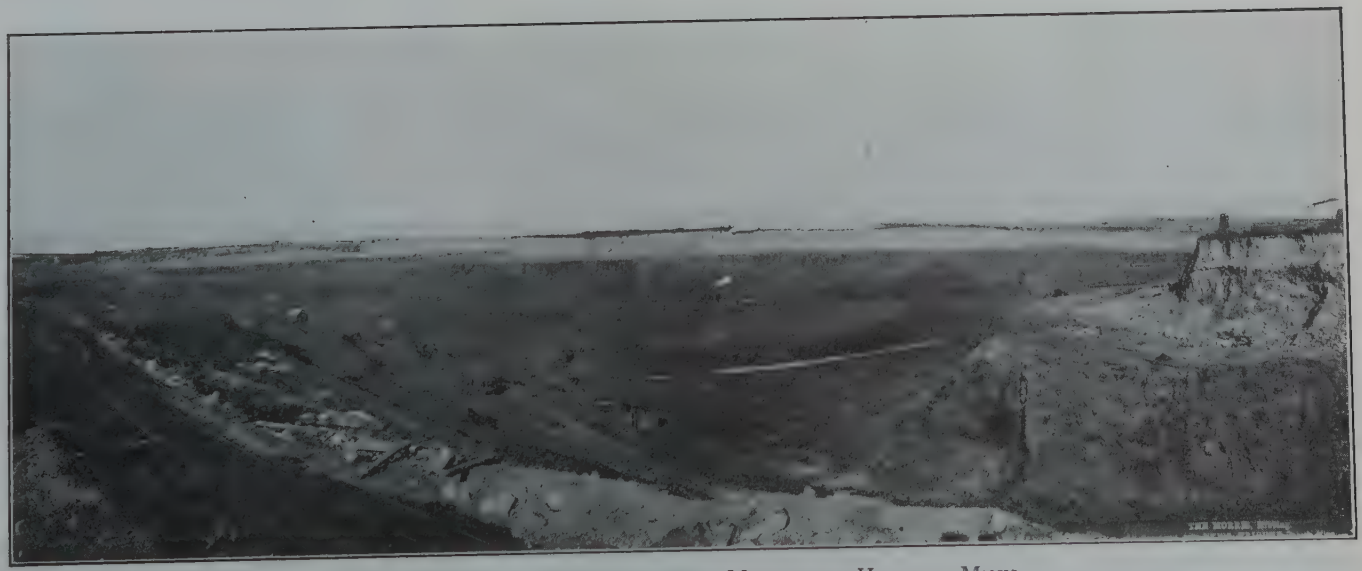

FIG. 4. THE MORRIS OPEN-PIT MINE NEAR HIBBING, MINN.

This mine, when I last heard, was operated by steam shovels, and they loaded 110 000 tons last year.

The Great Northern has a large ore yard at Superior, near the docks. I had charge of the construction of this yard. The ore trains of 125 50-ton cars are brought into a large receiving yard, and the road engine detached. A large switch engine then pushes these trains of 125 cars over a hump, and the cars run down

FIG. 5. STEAM SHOVEL LOADING IRON ORE IN THE MAHONING MINE.

the opposite side by gravity, into classification tracks, of which there are 40. Before the cars leave the mine yard, the ore is sampled, analyses made, and the dock office advised by telephone into just what pocket in the dock each car load is to go. A boat cargo from each mine is accumulated in the dock before shipping. After the ore cars are classified they are shoved up on to the docks in 18 car "cuts," and dumped through the bottom hoppers. The cars being 24 ft. long, and the ore dock pockets 12 ft., a train would naturally be dumped into every

Fig. 6. Ore Docks of the Duluth, Mesabi & Northern Railway, at Duluth, Minn.; Superior, Wis., in the Distance.

other pocket. The alternate pockets would be filled by other trains. On the two humps in the yard, there were four 150-ton track scales, two working and two emergency. Cars are weighed while in motion, and, surprising to say, very accurate results are obtained. All payments are made on basis of these weights, — mining, royalty, rail and water freight and the sale of the ore.

Duluth, Mesabi & Northern has a large yard at Proctor.

FIG. 7. LOADING IRON ORE AT THE DOCKS IN DULUTH, OF THE DULUTH, MESABI & NORTHERN RAILWAY.

This is on top of the Duluth Hill, about 6 miles from their ore docks. The D., M. & N. have a two per cent. grade, 105 ft. to the mile down the hill. Except for this hill — and this is only against empties — the D., M. & N. has no excessive grades from the mines to the docks. They have a high type double-track line, with many miles of rock ballast and steel ties. The Great Northern has a very flat grade line. From the mines to the Superior yard, the heaviest grade is 0.25 per cent., or 13 ft. to the mile. The Great Northern is famous for its low-grade lines.

The rail rate was formerly 80c. per ton unloaded in the ore docks. This was reduced a few years ago to 60c. The annual working season is about two hundred days, and during the balance of the year the entire plant is idle.

D., M. & N. ore docks, Figs. 6 and 7, are in Duluth, the four docks being about the same length as the Great Northern Docks. Duluth, you know, is situated on the edge of a very steep hill, about 300 ft. high, and the city runs along the lake shore for miles. It is a common saying that Duluth is 40 miles long, a half mile wide and a mile high. About 20 million tons are shipped through these docks per year.

Duluth & Iron Range has its docks at Two Harbors, about 30 miles east of Duluth. About 10 million tons are shipped from here, of which about 2 million is from the Vermilion range.

G. N. Ore Dock No. 3, under construction, is shown in Fig. 8. All work is done in the winter, when the docks are idle and when there is enough ice to work from.

While I was with the Great Northern, I built all of Dock No. 1, and doubled the length of No. 3, and rebuilt half of No. 2. All of these docks are about the same type of construction.

Dock No. 1 is 2 244 ft. long, 73 ft. high above water line, and 63 ft. wide; contains 17 million ft. of fir timber, and rests upon 16 000 piles 40 ft. to 80 ft. long. All timber was shipped 1 800 miles from Puget Sound points, requiring 1 000 cars. This timber would make a board walk 12 ins. wide from Boston to San Francisco. The piles, if placed end to end, would reach 170 miles. It cost a little over $1 000 000. We started to remove the old dock No. 1, containing about 6 million feet of timber, December 1, and started to drive piles in January; and the new dock was in service June 20.

These docks will load a boat very rapidly. The steamer *Wolvin* was loaded with 10 000 tons of ore in forty minutes at the G. N. docks, some years ago, and I think the record has since been beaten.

G. N. Ore Dock No. 4, Fig. 9, was the first concrete steel ore dock. It is about 1 800 ft. long and has only one post under a pocket, instead of 18 in the timber docks. Each post, however, is 36 ins. by 84 ins. It rests on a sand filled crib.

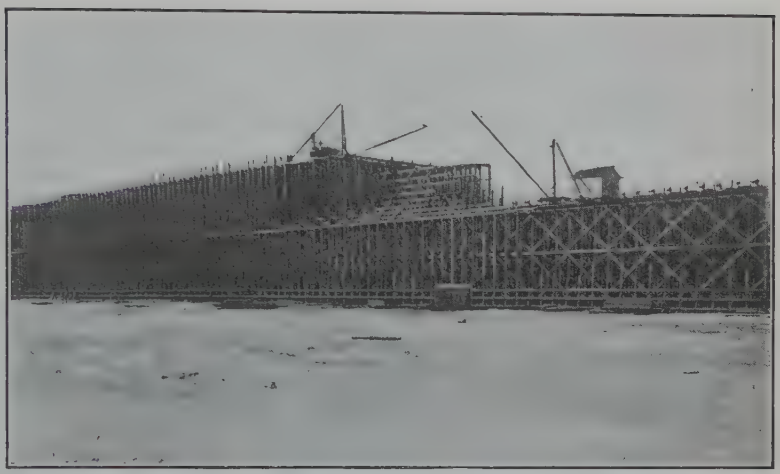

FIG. 8. ORE DOCK NO. 3 OF THE GREAT NORTHERN RAILWAY, UNDER CONSTRUCTION.

FIG. 9. ORE DOCK NO. 4 OF THE GREAT NORTHERN RAILWAY, AT ALLOUEZ BAY, SUPERIOR, WIS.

The top is of steel, of which there are 9 000 tons. The dock cost about $1 600 000. The depth of water in the slips is 24 ins. to 25 ft. Although there is no tide in Lake Superior, the depth of water will vary from year to year by several feet.

The lake ore boats are under-engined, and when unloaded are hard to manage. These boats usually come up from the lower lake ports loaded with coal, and return loaded with ore, grain, etc. A great many million tons of coal pass through the Duluth-Superior Harbor.

In 1917, the operation of boats was placed under a central control, and as an emergency measure the ore was placed in charge of a committee. Under this plan, ore was allotted to docks in accordance with the supply of railroad cars. In 1918, this plan is to be considerably broadened. This is a war measure, and considerably different from normal operation.

Those of you who are familiar with the operation on the Mesabi will appreciate that I have only made a hurried sketch of the whole process, as the operations are too extensive and vast to even grasp after visiting the district many times.

I wish to thank Mr. Irwin, of the Bay State Street Railway Company, Mr. Seward, general agent, and Mr. Hogeland, chief engineer of the Great Northern, and the editor of the *Iron Trade Review*, for their courtesies in furnishing me with data and photographs.

Vol. V MARCH, 1918 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

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THE HYDRAULIC LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

By George Edmond Russell,* Member of the Boston Society of Civil Engineers.

In presenting this paper to the Society, the author wishes to disclaim any intention of offering a detailed description of the Institute's new hydraulic plant, inasmuch as to do so would necessitate drawings which at this time are neither available nor can be prepared. The present object is to give such general facts and descriptions as will enable the engineering profession to learn of the beginnings which have been made and enlist its interest in the further development of this important project.

The laboratory, Fig. 1, is situated in that portion of the buildings which flanks the west side of the Main Court, and occupies, jointly with the steam and compressed air laboratories, the entire basement and two floors of the building. The portion devoted almost wholly to hydraulics, measures about 165 ft. in length, by 60 ft. in width, and includes the entire basement within this area and two half floors extending from the court wall to

* Associate Professor of Hydraulic Engineering, Massachusetts Institute of Technology.

Note. This paper, which will not be presented at a meeting of the Society, was intended to accompany the papers on the construction of the buildings printed in the January issue of the Journal, but was delayed in preparation.

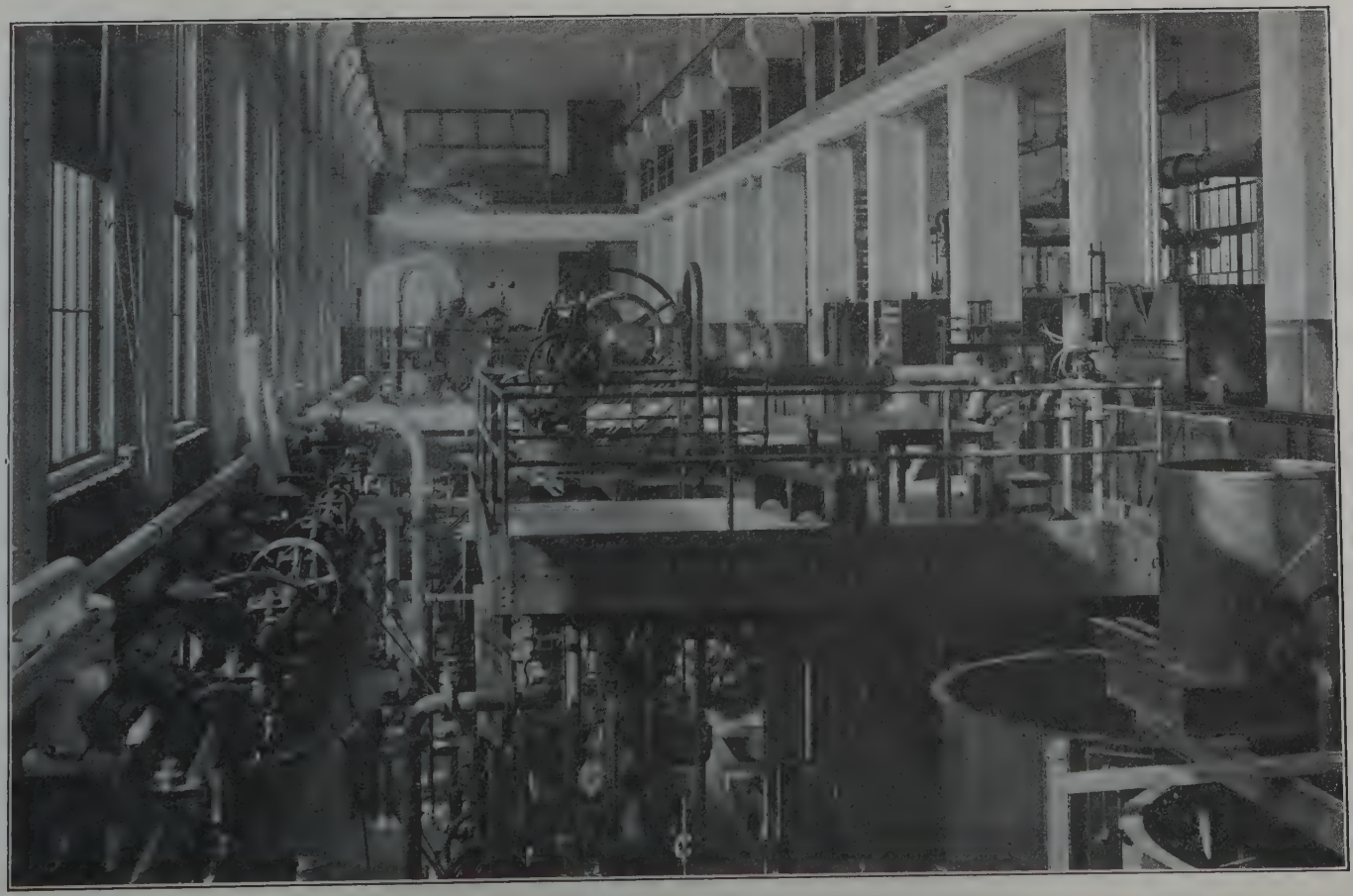

Fig 1. General View of Laboratory.

the center line of columns. Above one half of the basement floor there was left an open space extending through the two floors above, to serve as a craneway for the easy handling of the heavy pieces of apparatus with which the laboratory is equipped.

The general scheme of arrangment comprises the following

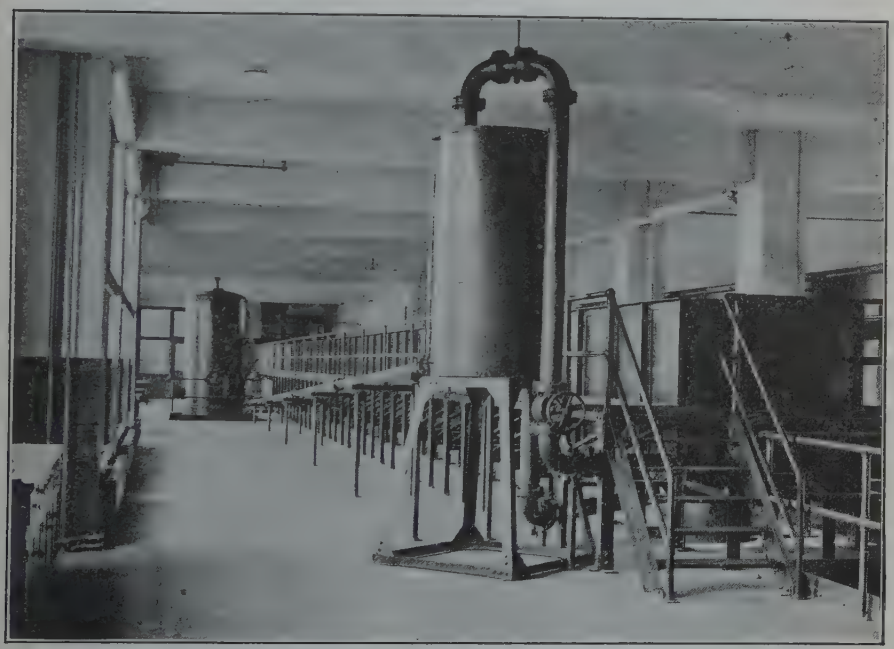

FIG. 2. STEEL HEAD RACE IN THIRD FLOOR, SHOWING RAM OUTFIT IN FOREGROUND AND TOP OF PRESSURE TANK IN BACKGROUND.

details: A system of canals in the basement floor for receiving and storing water taken from the Charles River Basin; a diversified collection of pumps to serve as objects of tests and to furnish the water through the distributing systems to the various experimental pieces of apparatus; a distributing system embracing piping for high- and low-pressure service, and both concrete and steel canals; and, finally, a collection of apparatus to be

used in connection with tests, illustrative work and original investigations.

The canal for storing the water is rectangular in cross-section, varying in width from 5 to 8 ft. and having an average depth of about 5 ft. It is endless, being arranged on the four sides of a rectangle whose length is 132 ft. and width 35 ft., and is so designed that it may be possible, by operating a large pumping unit, to simulate within it conditions of artificial stream flow. In all experimental work, water will be drawn from this canal and finally returned to it after passing through the apparatus which is being used. Its filling is accomplished by a gravity connection with the Charles River Basin aided by pumping.

In addition to the canal are two pits, 30 ft. deep, directly connected by means of valves with the water in the river basin. These serve as suction wells for investigating the performance of pumps under different conditions of suction head, the water level in them being controlled by the inlet valves which are opened or closed as the pump delivery is changed. By placing the pump to be tested on a raised platform above the pits, the suction head may be made as much as desired.

The pumping equipment consists of 15 units embracing numerous distinct types of varied size and capacity. The largest of these is a Worthington 30-in. centrifugal, directly connected with a 350 h.p. Ball angle compound engine. This unit is capable of pumping 22 000 gals. per minute against a head of 45 ft., and will be used for supplying water to the turbine testing flume. The two-stage type is represented by an 8-in. De Laval, steam turbine driven pump, and the three-stage by a 4-in. Jeansville pump operated by a Terry steam turbine.

The largest plunger pump is a Warren Duplex, 24 ins. by 15 ins. by 24 ins., designed for a maximum discharge of 1 500 gals. per minute against a 600-ft. head. This pump and the Jeansville centrifugal are used in connection with the compression tank to furnish water in all experiment work demanding high heads.

Of special interest are the arrangements for the testing of water turbines. While, owing to the exigencies of the war, the equipment is not yet complete, the major portion is in place,

and plans are ready for going ahead with the work in what is hoped to be the near future. Water from the large 30-in. centrifugal flows through a 30-in. Venturi meter, and by a vertical riser to the third floor of the laboratory, where it is delivered into a rectangular steel channel of 25 sq. ft., cross-section, Fig. 2. In this it runs for a distance of 135 ft. to the open flume

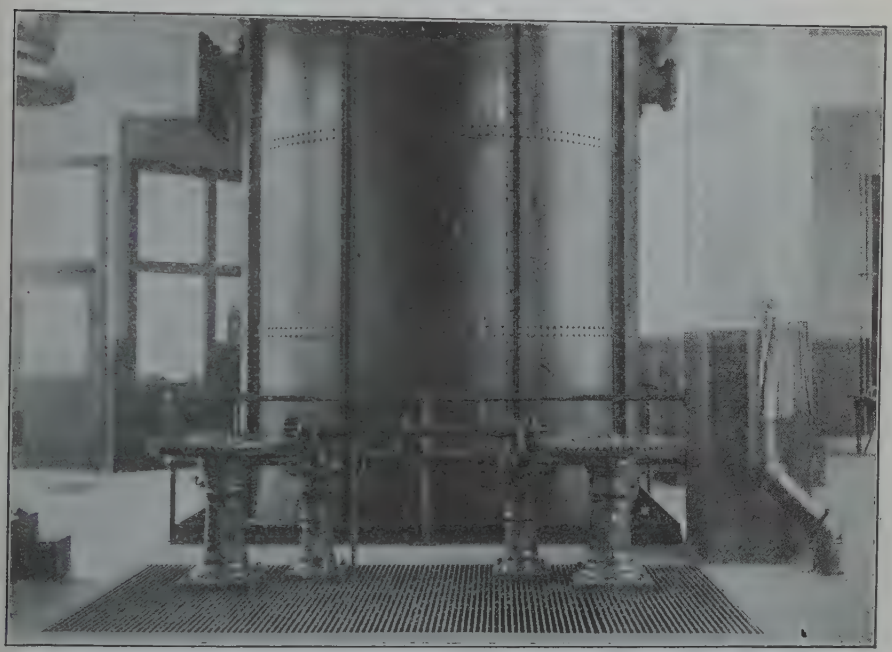

FIG. 3. BASE OF STEEL TURBINE FLUME AND HAND CONTROL GATES.

containing the turbine. The flume, Fig. 3, is an upright cylindrical steel tank, 12 ft. in diameter and 22.5 ft. high, with its base resting on the second floor of the laboratory. In its bottom is set the turbine, which discharges through a draft tube into a concrete tail race below. The back and side walls of the race are carried up from the basement to the second floor, and a large cast-iron gate placed across the race so that the water level immediately below the wheel and about the draft tube can be held at any desired level before being discharged down the race.

The design of the gate is peculiar, it being arranged to move up or down in the usual way, permitting the escape of water beneath it, but also provided with a series of long horizontal openings or sub-valves, which are operated by a secondary stem and so designed as to open successively, thus allowing close control of the water level. The stems of the valves reach through the floor above, where they are operated by the ordinary hand gate-jack (Fig. 3).

On passing the gate, the water flows through baffles and is then quieted in a straight reach of about 72 ft. before passing over the weir at the end of the race. From the weir it drops into the rectangular storage canal, completing the cycle of flow.

The weir just mentioned is a standard suppressed weir, 10 ft. in length and 5 ft. 6 ins. in height, although the height is quite easily alterable so as to permit changing the velocity of approach. One interesting feature connected with it is the fact that, in inserting the piezometer connections in the sides of the concrete channel, it was thought wise to make three separate sets of connections, each one duplicating the conditions of the Francis, Stearns and Bazin piezometers, with respect to size and location. Three separate hook gage pails allow the simultaneous measurement of the three heads. Already some work has been done by advanced students in comparing results so obtained, and, while the investigation has only begun, it looks as if interesting and perhaps valuable results might be reached.

Although the weir was designed to act as the standard mode of measurement in all turbine tests, it should be noted that a 30-in. Venturi meter was placed in the supply line and a third measurement is possible in the head race, where current meters may be used. At a future time it is proposed to install here a moving screen which shall hang vertically in the channel, fit with small clearance the cross-section of the same, and move down its length on a supporting track with the mean velocity (assumed) of the water. Experiments, at Wisconsin, and on a small scale at the Institute, already indicate that a high degree of precision may be thus reached in measuring mean velocities in artificial channels. It would seem, therefore, as if the measurement of the quantity of water passing the turbine might be precisely made.

The power output of the wheel will be measured by an Alden absorption dynamometer mounted directly on the turbine shaft. The setting of the turbine is similar to that at the Holyoke Flume, the wheel being hung on a suspension bearing which is capable of vertical adjustment.

The wheel to be first installed is an 18-in. S. Morgan Smith

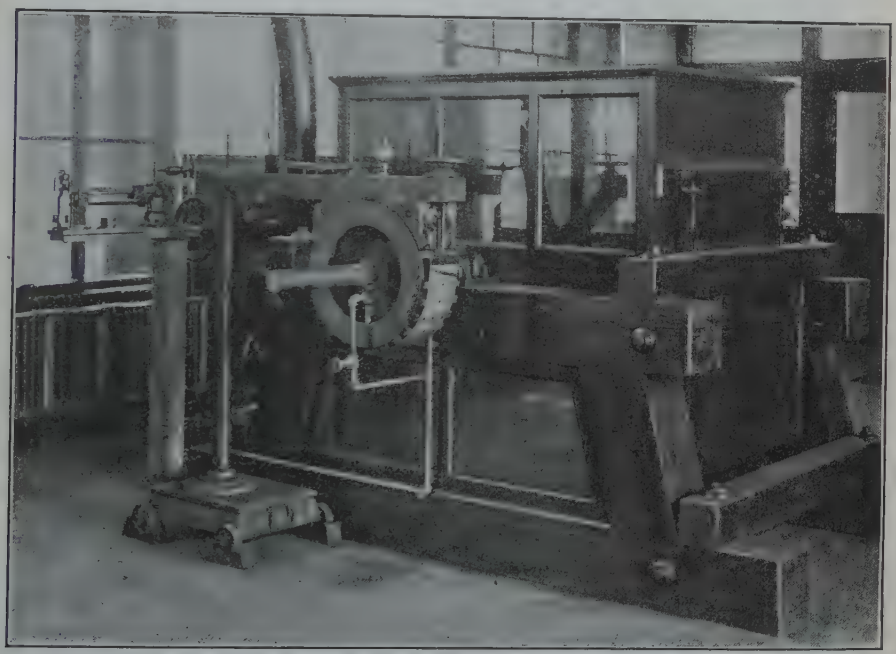

Fig. 4. Pelton Wheel Unit with Brake.

wheel, specially designed and donated by the makers for the purpose of experimental work. It has been tested at Holyoke, so that any future work done here can be compared with results obtained under Holyoke conditions. The maximum head which can be obtained in the flume will be about 34 ft., this being divided into a pressure head above the wheel of 22.5 ft. and a draft head of 11.5 ft. With this fall and a maximum discharge of 50 sec. ft., a gross power of about 193 h.p. may be obtained.

At present the laboratory is equipped with three turbines of the tangential type, one an American 30-in. wheel, a Pelton 36-in. wheel, Fig. 4, and a modern Pelton-Doble wheel, 24 ins. in diameter. These are nozzle-fed with water pumped into the pressure tanks, of which there are two (Fig. 5). Both of the latter are cylindrical, set vertically, and capable of furnishing

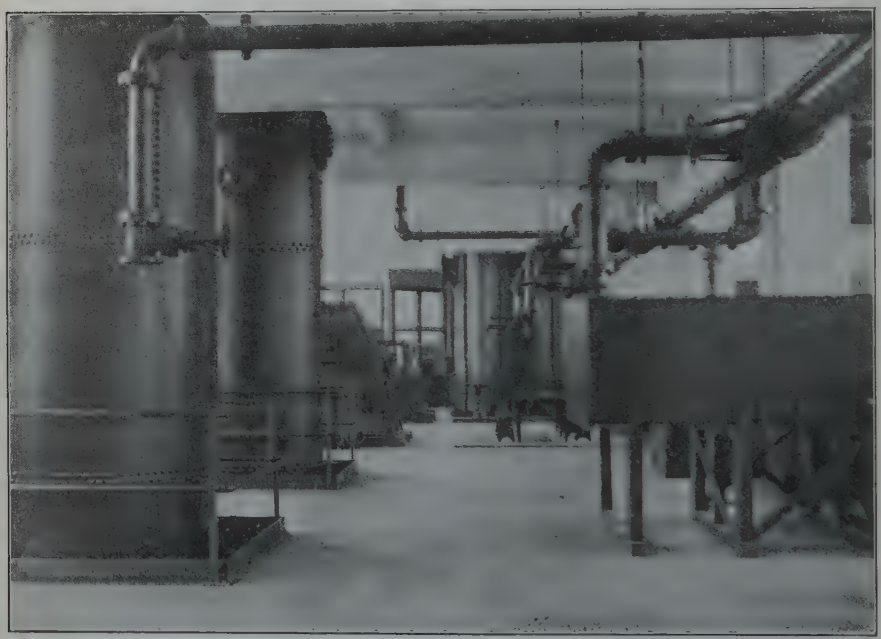

Fig. 5. Pressure Tanks and Weir Boxes on Second Floor.

heads as high as 600 ft. Assuming that, under high pressures, the water will gradually absorb the air cushion at the top of the tank, arrangements will be made for supplying compressed air to make up the loss so incurred.

The tanks are equipped with openings at different levels, to permit the insertion of experimental orifices, nozzles, mouthpieces, and any apparatus for using water under a wide range of head. The position of the tanks is such that their discharge

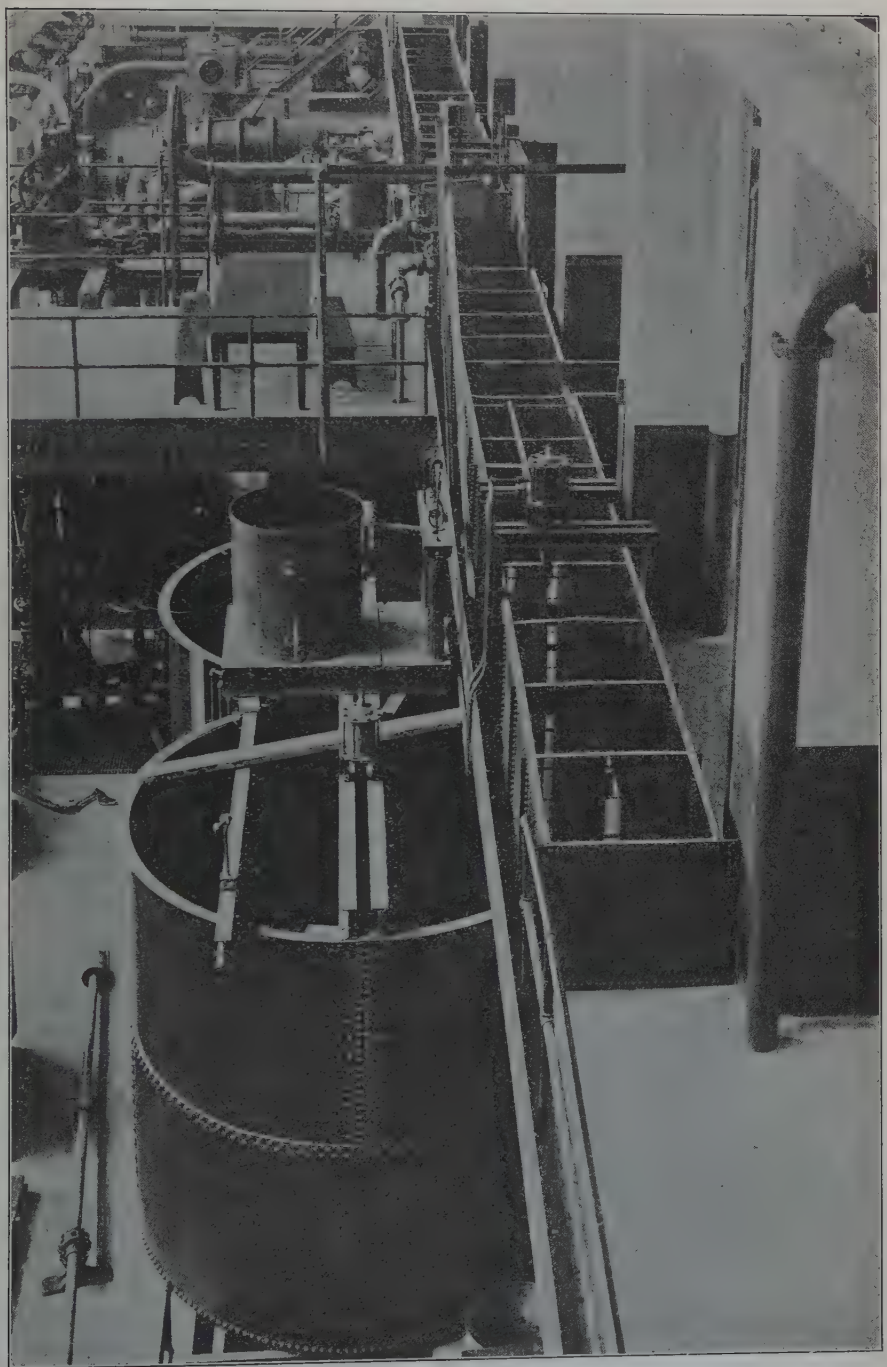

FIG. 6. NEAR VIEW OF COLLECTING TROUGH, SHOWING GATE-OPERATING VALVE AND CALIBRATED TANK.

valves are directly over the canals in the basement. The larger of the two tanks is 35 ft. high, extending through the upper floor of the laboratory, thus giving opportunity for high-pressure work on all floors. This tank is 6 ft. in diameter and made from 1-in. steel plate.

As far as possible, the discharge from the various pumps and wheels will be measured over weirs, but arrangements have been made whereby all but the largest pieces of apparatus may have their discharges measured in calibrated steel tanks which rest on the basement floor and discharge into the canal (Fig. 6). There are four of these tanks, — two 10 ft. in diameter and 12 ft. tall, each with a capacity of 7 000 gals., and two 6 ft. in diameter and 10 ft. tall, with a capacity of 2 100 gals. each. Above these tanks runs a steel collecting trough, easily accessible from different parts of the laboratory, into which water comes from any particular piece of apparatus and from which it will flow through valves into the tanks below. These valves, as well as those which empty the tanks, are operated by water pressure, and the design makes it possible for the operator to shift the discharge quickly from one tank into another or to empty a tank without moving from his position.

No equipment has so far been installed for pipe experiments, but it is planned to utilize space on the third floor for this purpose, where connection can be easily made with the large pressure tank which rises from the basement through both floors. Here, too, will be installed the apparatus for the calibration of nozzles. At present there is on this floor, beside the steel channel forming the head race to the turbine flume, two rams which operate under a head of about 8 ft.

This latter is obtained by pumping into an elevated steel tank equipped with a constant level overflow. Waste water from the rams, and also the discharge from the same, is returned to the basement and weighed in large tanks. At present the equipment is composed of a twin Gould ram and one Rife.

Vol. V MARCH, 1918 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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THE EFFECT OF HEATING CONCRETE MATERIALS IN THE MIXER.

By H. E. Sawtell,* Member Boston Society of Civil Engineers.

The following is a description and a statement of the results of a test, made for Mr. Charles T. Main, which may be of value to engineers, for the purpose of determining whether heating, in the mixer, of materials by a method being used during cold weather, had any effect on the strength of the concrete.

The apparatus used consisted of a small tank for kerosene, a pump to compress air in the tank, and a connecting pipe to a burner, fastened to the mixer just over the receiving chute.

The kerosene was forced by the compressed air through the connecting pipe into the burner, where it burned with a blue flame. The flame then passed down a flattened pipe into the mixer. The flattened pipe stopped just inside of the mixer at the top of the opening, and the flame shot from there to the center of the mixer. The flame, after leaving the pipe, was about 9 ins. wide, 6 ins. thick, and 1 ft. long.

The concrete materials entered under the flame, and apparently did not come in direct contact with it at any time. The air in the mixer did get very hot, however, and the concrete

* Structural Engineer, with Charles T. Main, 201 Devonshire Street, Boston.

Note. This paper will not be presented at a regular meeting of the Society, but discussion is invited, to be received by W. L. Butcher, Editor, 715 Tremont Temple, Boston, before May 10, 1918, for publication in a subsequent issue of the Journal.

dried out so fast that it was necessary to add water repeatedly during the mixing. As the effect of the rapid heating and drying out was doubtful, it was decided to make a test.

Six cylinders, made of 1 : 2 : 4 concrete, each 8 ins. in diameter and 16 ins. high, were made as follows.

Sand and stone were put into mixer, and turned for ten minutes. The cement was then added, followed by the water. The mixer was started at 5.40 P.M.

First cold sample taken at 6.10 P.M.; temperature 48 degrees Fahr.

Second cold sample taken at 6.15 P.M.; temperature 48 degrees Fahr.

Third cold sample taken at 6.25 P.M.; temperature 50 degrees Fahr.

Started heater at 6.25, and temperature at start was 50 degrees Fahr.

First hot sample taken at 6.45 P.M.; temperature 92 degrees Fahr.

Second hot sample taken at 6.50 P.M.; temperature 98 degrees Fahr.

Third hot sample taken at 6.55 P.M.; temperature 95 degrees Fahr.

All temperatures were taken by inserting a thermometer into the concrete of each cylinder as soon as filled. The mixer was run continuously with the same batch from 5.40 to 6.55 P.M.

It was necessary to add a little water before taking the third hot sample, which accounts for the drop in temperature.

The three cold cylinders were marked 2, 4 and 6 respectively, while the three hot cylinders were marked 1, 3 and 5 respectively.

All cylinders were then placed in a damp atmosphere at the bottom of an excavation 10 ft. deep and covered with canvas. In ten days they were removed to an unheated room, where they remained for about a week, after which they were carefully boxed for shipment and sent to Professor Hayward at the laboratory of the Massachusetts Institute of Technology, for testing. They were crushed at the end of twenty-eight days with the following results.

No. of Cylinder.	Temperature.	Maximum Load in Lbs.	Compressive Strength. Lbs. per Sq. In.
1	Hot	71 000	1 412
2	Cold	137 000	2 736
3	Hot	65 400	1 303
4	Cold	144 000	2 865
5	Hot	40 000	795
6	Cold	117 400	2 336

The average strength of the hot concrete was about 44 per cent. of that for the cold concrete.

Professor Hayward's report states that cylinders 1, 3 and 5 contained a large number of surface cracks, of varying depth.

The bonding of the aggregate in numbers 1 and 3 cylinders was not nearly as good as in the case of numbers 2, 4 and 6, and the bonding of the aggregate in number 5 was especially poor.

It appears from these tests that there is a marked reduction of strength in concrete when heated by the method described; but, as it may be unsafe to form judgment based on such a small number of tests, we should like to see the matter investigated further.

Vol. V MARCH, 1918 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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DISCUSSION OF THE FOUNDATIONS OF THE NEW BUILDINGS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

By J. R. Worcester,* Member Boston Society of Civil Engineers.

The report of the experimental work in connection with the foundations of the Technology buildings is a valuable addition to the meager literature upon pile foundations, and the care taken in testing the ground and recording the results of the tests gives the information thereby obtained unusual weight.

The pile driving and load tests recorded do not make entirely clear the reasons which led to some of the rules adopted, though undoubtedly the latter were justified by information not easily obtainable from the reports. For instance, how was it determined that spruce piles could not have been driven everywhere in place of oak? According to Rules 1 and 2, it was determined to use oak whenever a 2 300-lb. hammer falling 10 ft. produced a penetration of less than $1\frac{1}{4}$ ins. The first ten piles of Group A, which broke, were apparently subjected to considerably heavier driving than this, and we do not find evidence

* Of J. R. Worcester & Co., Consulting Engineers, 79 Milk Street, Boston.

that they could not have been driven with a lesser fall far enough into a " hard " soil to have carried the required loads with safety.

It would not appear that any great advantage was obtained from the attempt to determine the load causing $\frac{1}{16}$-in. settlement. Comparing these loads with the ultimate capacity, we find a very variable factor of safety, as shown in Table 1.

TABLE 1.

Pile No.	Load Causing $\frac{1}{16}$-In. Settlement.	Maximum Load.	Factor of Safety.
14 a	11 000	77 400	7.0
2 a–4	14 000	29 860+	2.1+
12 d	18 000	89 800	5.0
2 a–2a	20 000	62 400+	3.1+
12 g	30 860	83 500	2.7
11 a	25 600	77 400	3.0
10 a	25 760	59 000+	2.3+
13 g	16 000	43 000+	2.7+
11 d	18 000	64 000	3.6
n 8	19 600	87 000	4.4

It is evident that the load at the $\frac{1}{16}$-in. settlement is little indication of the maximum capacity. There are two good reasons for this. In the first place, the elasticity of the pile must affect this observation to a marked degree, especially when the support is mainly near the tip and there is a considerable length in material having little supporting power. Roughly speaking, a length of 20 ft. under a load of 20 000 lbs. would cause an elastic shrinkage of $\frac{1}{10}$ in. This indicates that the settlements of $\frac{1}{16}$ in. recorded may very easily be entirely elastic, and not due to any yielding of the bottom. Another reason why $\frac{1}{16}$ in. is not a very useful point in the settlement upon which to rely, is the difficulty of observing the settlements with sufficient accuracy.

It would appear that the load at $\frac{1}{4}$ in. is more reliable and useful as an index of the capacity. Table 2 gives the results of the same tests as before arranged with regard to their capacity at $\frac{1}{4}$-in. settlement.

TABLE 2.

Pile No.	Load Causing ¼-In. Settlement.	Maximum Load.	Factor of Safety.
14 a	73 000	77 400	1.06
2 a–4	28 000	29 860+	1.06+
12 d	75 200	89 800	1.19
2 a–2a	43 000	62 400+	1.45+
12 g	66 000	83 500	1.26
11 a	43 500	77 400	1.78
10 a	41 100	59 000+	1.44+
13 g	28 000	43 000+	1.54+
11 d	28 000	64 000	2.29
n 8	53 700	87 000	1.62

So far as can be judged from these tests, it would be entirely safe to allow for a working load one half that causing ¼-in. settlement. The factor of 2½ actually used was undoubtedly conservative.

In the design of the concrete footings, it is not clear why it was thought necessary to increase the depth on account of a possibility that piles immediately under the load will be stressed somewhat higher than those at the edges. Even if this were the case, — and it is by no means certain that it would be, — it is hard to see how the unequal distribution of the load would have anything but a beneficial effect upon the footing.

In his discussion, Mr. L. M. Hastings has touched upon the vital question which must occur to any one familiar with the history of structures in the locality where these buildings have been placed. It will be a very pleasing surprise if a gradual settlement of the whole group does not develop, through the subsidence of the glacial deposit below the mud. Such a settlement might not be noticeable or injurious if it were uniform over the hole area, but the area covered by the connecting buildings is so large that it would appear hardly probable that they could all move together. The outcome will be awaited with great interest.

MEMOIRS OF DECEASED MEMBERS.

OTIS FRANCIS CLAPP.*

Otis Francis Clapp, son of James Otis and Lucia Kingman Clapp, was born in Boston, Mass., September 26, 1843, and died at Providence, R. I., March 3, 1917. He was educated in the public schools and Hunt's Academy at North Bridgewater, now Brockton, Mass. He entered the office of Shedd and Edson in Boston, where he received his early training in engineering, and in 1867 was sent from that firm's office to Providence, R. I., to make the preliminary surveys for the first municipal water-works system, which provided for taking the water supply from the Pawtuxet River and which later was adopted.

In 1872 Mr. Clapp was placed in charge of preparing plans for a sewerage system for the city of Providence. A large part of the city's sewers and the precipitation works for the disposal of sewage were constructed under his direction.

In May, 1897, he was appointed city engineer to succeed J. Herbert Shedd, resigned, an office which he held for eighteen successive years. He was then appointed first assistant in the city engineer's department on special work in connection with the improvement of the Moshassuck River channel, and held that position for nearly a year, when he resigned on account of failing health.

Mr. Clapp was connected with the engineering work of the city of Providence for more than fifty years, being more particularly interested in water works and sewers. He joined the Boston Society of Civil Engineers in 1888, and was Vice-President of the Society in 1904 and 1905, and at the time of his death he was a member and a director of the American Society of Civil Engineers.

In November, 1869, he married Anna Isabella Sweetland, whom he survived about two years.

Mr. Clapp was a man of pleasing personality, modest and unassuming in manner, and of a genial temperament which had attracted to him many friends.

* Memoir prepared by Wm. D. Bullock and Irving S. Wood.

HENRY AUGUSTUS HERRICK.*

Henry A. Herrick was born November 26, 1861, at Brooklyn, N. Y.

His parents were Henry Walker Herrick and Clarrissa Harlow Parkinson.

His parents moved to Manchester, N. H., when he was four years old. He was educated in the public schools in Manchester, graduating from the high school at the age of nineteen years.

His first work after graduation was with the Amoskeag Manufacturing Company at Manchester, in connection with the design, construction and equipment of cotton mills. He was later, in succession, engaged in similar work at the Methuen Mills, Methuen, Mass.; at Willimantic, Conn.; with F. P. Sheldon, mill engineer, Providence, R. I.; and at the Schuylerville Mills.

In 1890 he went to Spokane, Wash., where he designed and supervised the construction of the dam and power station which is still in operation.

On January 14, 1891, he was married and went to Great Falls, Mont., where he designed and supervised the construction of the Black Eagle Falls Dam and power plant for the Boston and Montana smelter.

In the latter part of 1895 he became associated with Dean & Main, engineers, and was engaged in the design and supervision of construction of many textile and other industrial plants. Upon the dissolution of this firm in 1907, he continued his association with Charles T. Main.

The most interesting, valuable and effective work was done by Mr. Herrick in the last ten years of his life, during which time he had charge of the design and construction of some of the largest and best hydro-electric developments in the country; namely, the Rainbow Falls development and the Great Falls development on the Missouri River near Great Falls, Mont., the Thompson Falls development on Clarks Fork of the Columbia River, at Thompson Falls, Mont., and he was just nearing the completion of his work on the Holter development, near

* Memoir prepared by Chas. T. Main.

Helena, Mont., when he was stricken down by heart failure and died immediately. All of these developments formed a part of the system of the Montana Power Company, and aggregated about 250 000 h.p.

During the time that the above-mentioned work was in progress, and between the ending of one and beginning of another undertaking, he made many examinations and reports on other projects and acted as consulting engineer on several.

Mr. Herrick had developed a systematic analysis of dams, based on his many years of close study and experience in designing such structures. All of the many fundamentals, such as geological formation, seepage, drainage, upward pressure, shock and dissipation of energy due to overflow, flood conditions, etc., received proper consideration in his analysis.

His early training in design and construction enabled him to design the buildings for power stations in a most acceptable manner. He mastered the electrical problems with great ease.

He was a great student, and a fine mathematician, and one of the best of the type represented by self-educated engineers. His character was of the highest, and his dealings with men above and below him were always characterized with fine courtesy and uprightness.

He was a member of the Boston Society of Civil Engineers, joining November 15, 1911, and of the American Society of Civil Engineers, which he joined in 1890. He was also a member of the Engineers Club, Boston; the Fresno Club, Fresno, Calif.; Silver Bow Club, Butte, Mont.; and other societies.

His principal recreation was trap and target shooting, hunting and fishing, and he took as much pleasure in anticipation as in the rare actual outings which his busy life allowed him.

Vol. V MARCH, 1918 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
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INDEX TO ADVERTISERS.

	Page
A. B. See Electric Elevators, 111 Devonshire St., Boston	XIV
Aberthaw Construction Co., 27 School St., Boston	XIII
Adams, H. S., 108 Ames Building, Boston, Mass.	III
Aspinwall & Lincoln, 3 Hamilton Pl., Boston	III
Associated Architects Printing & Supply Co., 144 Congress St., Boston	XIII
Bay State Dredging and Contracting Co., 62 Condor St., East Boston	IX
Beattie, Inc., Roy H., 70 Kilby St., Boston	XII
Bishop, J. W., & Co., 683 Atlantic Ave., Boston	X
Blair, Isaac, & Co., Inc., 433 Harrison Ave., Boston	X
Bond, Harold L., Co., 383 Atlantic Ave., Boston	VII
Buss, Edward A., 85 Water St., Boston	III
Coleman Bros., 1 Marginal St., Chelsea	XII
Dixon Crucible Co., Jersey City, N. J.	XII
Eastern Bridge and Structural Co., Worcester	XIV
Fay, Spofford & Thorndike, 308 Boylston St., Boston	III
Fort Hill Press, 176 High St., Boston	XIV
Fuller, George W., 170 Broadway, New York	III
Gow, The Charles R., Co., 166 Devonshire St., Boston	XI
Hall, John G., & Co., 114 State St., Boston	XII
Harrington, Ephraim, 20 Pemberton Sq., Boston	III
Hersey Mfg. Co., South Boston	XVI
Holbrook, Cabot & Rollins Corpn., 6 Beacon St., Boston	VI
Holzer, U., 25 Bromfield St., Boston	IX
Hughes, Edward F., 8 Oliver St., Boston	XII
Jackson, D. C. & Wm. B., 248 Boylston St., Boston	III
Jonsberg, F. F., Co., 733 Old South Building, Boston	X
Ledder & Probst, 56 Franklin St., Boston	XII
Ley & Co., Inc., Fred T., Springfield, Mass.	XV
Main, Charles T., 201 Devonshire St., Boston	II
Metcalf & Eddy, 14 Beacon St., Boston	III
Morse, William F., 90 West St., New York	III
New England Bureau of Tests, Inc., 12 Pearl St., Boston	IV
New England Foundation Co., Inc., 70 Kilby St., Boston	XII
New England Sand & Gravel Co., West Peabody, Mass.	VII
Old Corner Book Store, 27 Bromfield St., Boston	XII
Palmer, John E., 1012 Old South Bldg., Boston	XII

	Page
Penn Metal Co., 201 Devonshire St., Boston	IV
Pennsylvania Cement Co., 161 Devonshire St., Boston	X
Perrin, Seamans & Co., 57 Oliver St., Boston	XI
Rideout, Chandler & Joyce, 178 High St., Boston	XII
Rockport Granite Co., Rockport, Mass.	V
Simpson Bros. Corpn., 166 Devonshire St., Boston	V
S–M–I Engineering Company, 136 Federal St., Boston	IV
Smith, B. F., & Co., 60 Federal St., Boston	XII
Spaulding-Moss Co., 44 Federal St., Boston	XI
Stone & Webster, 147 Milk St., Boston	VIII
Thompson, Sanford E., 136 Federal St., Boston	III
Thorpe, Lewis D., 201 Devonshire St., Boston	III
Tucker, Edward A., Co., 683 Atlantic Ave., Boston	V
Waldo Brothers, Boston	IX
Warren Foundry and Machine Co., 111 Broadway, New York	VII
Weston & Sampson, 14 Beacon St., Boston	III
Whitman & Howard, 220 Devonshire St., Boston	IV
Witherow Steel Co., 185 Devonshire St., Boston, Mass.	XIII
Wood, R. D., & Co., Philadelphia	VII
Worcester, J. R., & Co., 79 Milk St., Boston	IV

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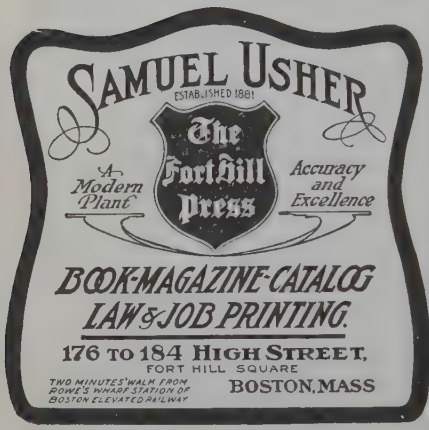

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